

### **Remarks/ Arguments**

Claims 1 to 15 were acted on by the Examiner. Claims 1, 2, 6, 9, 12, 13, 14 and 15 have been amended. Claims 16 to 20 have been added. Accordingly, claims 1 to 20 are pending in the present patent application.

The Office Action dated September 26, 2006 ("the Action") includes rejections under 35 U.S.C. §§ 103(a), and 112, second paragraph. In view of the following remarks, reconsideration and withdrawal of the rejections are requested respectfully.

### **Discussion of the Claim Amendments**

Claims 1 and 15 were amended to change "cleaning agent" to "cleaning gas" to establish an antecedent basis for the term "cleaning gas" used in the dependent claims.

Claims 2, 6, 9, 12, 14, and 15 were amended to include a proper Markush group or to make clear that the members of the group are being claimed in the alternative.

Claims 16 to 20 were added to cover the corresponding features of claims 2 to 6 respectively.

### **Summary of the Invention**

Applicants' claimed invention is directed to a process for removing TiO<sub>2</sub>-containing substances from a reactor that is used to coat one or more articles with TiO<sub>2</sub>. The process includes the following steps:

- (1) providing the reactor to be cleaned wherein the reactor contains a chamber comprising a surface at least partially coated with a substance comprising TiO<sub>2</sub>;
- (2) adding to the reactor a reactive gas comprising at least one cleaning gas;
- (3) reacting the substance with the reactive gas to form at least one volatile product; and
- (4) removing from the reactor the at least one volatile product to clean the reactor.

Applicants' process is also directed to using the above cleaning process following a process for the deposition of  $\text{TiO}_2$  coating on a glass article.

$\text{TiO}_2$  deposition processes not only deposit  $\text{TiO}_2$  on the surface of the desired article but also deposit  $\text{TiO}_2$  unproductively upon the inner walls or other surfaces of the reactor chamber. This  $\text{TiO}_2$  residue can cause a number of problems. For example, the residue can become thick enough to flake off and contaminate the  $\text{TiO}_2$  coating on the article. Moreover, the residue may affect the operation of the reactor resulting in the need to change the deposition process parameters. (See Applicants' specification at ¶ 4).

$\text{TiO}_2$  is non-volatile and relatively inert. Prior-art processes for removing  $\text{TiO}_2$  residue involve mechanically removing the residue (scraping, abrading, brushing and/or shot blasting). (See Applicants' specification at ¶ 5). Obviously, this is less than an ideal process as the reactor is subject to costly down time.

Applicants' have made the surprising discovery that reactive cleaning gases can be used effectively to remove  $\text{TiO}_2$ -containing substances from walls of a reactor chamber. By reacting the  $\text{TiO}_2$ -containing substances under certain conditions with, for example, chlorine or fluorine-containing gases, Applicants' have been able to convert the non-volatile and inert  $\text{TiO}_2$  into a volatile product that can be removed without the need to open the reactor. (See Applicants' specification at ¶¶ 10-11). Although  $\text{TiCl}_4$  is more volatile than Titanium fluorine compounds, Applicants' made the surprising and unexpected discovery that certain fluorine-containing chemical gases were far more effective at removing  $\text{TiO}_2$  residues than chlorine-containing chemical gases. (See Applicants' specification at ¶ 13).

#### **Discussion of the Rejections Under 35 U.S.C. § 112**

Claim 13 has been rejected under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which

applicant regards as the invention. In particular, claim 13 has been rejected because the recitation “the fluorine-containing reactive gas” in line 1 of claim 13 lacks antecedent basis.

Applicants have amended claim 13 to depend from claim 5 rather than claim 1. Claim 5 recites a “fluorine-containing cleaning gas.” Claim 5 also depends from claim 1 which recites “a reactive gas comprising at least one cleaning gas.” Accordingly, there is now sufficient antecedent basis for “the fluorine-containing reactive gas” of claim 13, and Applicants request respectfully the withdrawal of this rejection under 35 U.S.C. § 112, second paragraph.

Claims 2-7, 9-12, 14 and 15 have also been rejected under 35 U.S.C. § 112, second paragraph, as being indefinite for failing to particularly point out and distinctly claim the subject matter which applicant regards as the invention. The Action asserts that claims 2, 6, 9, 12, 14, and 15 are improper Markush claims as they do not use proper Markush language (group consisting of...and) or refer to the choices in the alternative.

In response, Applicants have amended claims 2, 6, 9, 12, 14, and 15. In claims 2, 6, 14, and 15, Applicants have amended the claims so that the claims recite the proper Markush language, “selected from the group consisting of.” In claims 9 and 12, Applicants have amended the claims to make clear that the members of the group are being claimed in the alternative. Accordingly, reconsideration and withdrawal of this rejection under 35 U.S.C. § 112, second paragraph is requested respectfully.

#### **Discussion of the Rejections Under 35 U.S.C. § 103(a)**

Applicants respectfully traverse these rejections as the Examiner has not established a *prima facie* case of obviousness. “To establish a *prima facie* case of obviousness, three basic criteria must be met. First, there must be some suggestion or motivation, either in the references themselves or in the knowledge generally available to one of ordinary skill in the

art, to modify the reference or to combine reference teachings. Second, there must be a reasonable expectation of success. Finally, the prior art reference (or references when combined) must teach or suggest all the claim limitations.” MPEP § 2143. Here, the combined references do not teach or suggest all the claim limitations nor is there a suggestion or motivation to combine the references.

Sandhu et al. in view of Giolando

Claims 1-4, 12 and 14-15 are rejected under 35 U.S.C. § 103(a) as being unpatentable over U.S. Patent No. 6,554,910 to Sandhu et al. in view of U.S. Patent Publication 2002/0071912 to Giolando.

Sandhu et al. is directed to a method for removing  $\text{TiCl}_4$ -derived residues in semiconductor processing chambers with treatment gases that convert the residues to substantially stable and/or removable materials. For example, Sandhu et al. discloses removing  $\text{TiCl}_4$ -derived residues by neutralizing and/or removing using a treatment gas comprising ammonia. (Sandhu et al. at col. 2, lines 52-54). Sandhu et al. also discloses removing  $\text{TiCl}_4$ -derived residues containing chlorides of titanium in forms having three or less chlorine residues. In particular, Sandhu et al. teaches flooding a reactor having  $\text{TiCl}_4$ -derived residues with  $\text{NH}_3$  to form substantially stable and removable adduct salts. The reactor is then opened for wet or mechanical cleaning. (Sandhu et al. col. 6, lines 30-35). Sandhu et al. also teaches using  $\text{Cl}_2$  or  $\text{HCl}$  to convert  $\text{TiCl}$ ,  $\text{TiCl}_2$  or  $\text{TiCl}_3$ -containing residues to  $\text{TiCl}_4$ -containing treatment products for removal. Sandhu et al. does not disclose a process for removing  *$\text{TiO}_2$ -containing substances*.

In contrast, claims 1 and 15 are directed to processes for removing  $\text{TiO}_2$ -containing substances from a reactor that is used to coat one or more articles with  $\text{TiO}_2$ . Moreover, claim 1 specifically recites the step of reacting a  $\text{TiO}_2$ -containing substance with a reactive

gas. Sandhu et al. does not teach these claim limitations. While Sandhu et al. is directed to a cleaning process, Sandhu et al. speaks of removing  $\text{TiCl}_4$ -containing substances not  $\text{TiO}_2$ -containing substances. In fact, Sandhu et al. is directed at avoiding the undesirable production of  $\text{TiO}_2$ -containing substances in the first place.

Reactions between air and/or moisture and  $\text{TiCl}_4$ -derived residues deposited on reactor chamber walls are undesirable for many reasons. White smoke generated from these reactions actually consists of fine particles, such as of the form  $\text{TiO}_x$ , which may eventually settle from the air, coating surfaces within the fabrication clean room where they may contaminate devices or wafers. In addition, products of the above reaction, such as  $\text{HCl}$  and/or chlorine may be prone to causing accelerated corrosion of aluminum chamber walls.

Accordingly, Sandhu et al. does not teach the removal of  $\text{TiO}_2$ -containing substances but rather teaches the removal of substances such as  $\text{TiCl}_4$  which if exposed to moisture or oxygen could convert to  $\text{TiO}_2$ .

The Giolando et al. reference does not cure the deficiencies in Sandhu et al. Giolando et al. is directed to ligated compounds of tin, titanium, and zinc for preparing uniform, high quality metal oxide coating on glass and other substrates. Giolando et al. also discloses a process for the chemical vapor deposition of a metal oxide film onto a heated substrate by using such ligated compounds. In the background section, Giolando et al. disclose that titanium oxide films have been prepared by using titanium tetrachloride. (Giolando et al. at ¶ 4). Giolando et al. does not disclose a cleaning process much less a cleaning process designed to remove the non-volatile and relatively inert  $\text{TiO}_2$ .

In the Action, Giolando et al. is relied upon for the unremarkable proposition that  $\text{TiCl}_4$  can be used during a CVD process to deposit titanium oxide on a suitable substrate. Applicants do not dispute that it was known that  $\text{TiCl}_4$  can be used to deposit a film of  $\text{TiO}_2$  on a substrate. However, like Sandhu et al., Giolando et al. does not teach the removal of  $\text{TiO}_2$  from the chamber surfaces. In fact, the Examiner states Giolando is evidence of "a procedure well known in the art that leaves  $\text{TiCl}_4$  deposits on the chamber surface." (Action

at p. 5). Accordingly, neither Sandhu et al. nor Giolando et al. teach the removal of  $\text{TiO}_2$ -containing substances.

Moreover, the Action does not provide a valid suggestion or motivation to combine these references. The Action states that "it would have been obvious to one of ordinary skill in the art at the time of the invention to modify Sandhu et al. to explicitly state that the  $\text{TiCl}_4$  is used to deposit titanium oxide as taught by Giolando in order to use a precursor well-known in the art to deposit metal source materials for semiconductor applications." (Action at p. 5). Whether one of skill in the art would be motivated to use  $\text{TiCl}_4$  to deposit titanium oxide for semiconductor applications is besides the point. Applicants' claimed process is directed to removing  $\text{TiO}_2$ -containing substances by using a reactive gas. This combination of references does not teach the claimed process. Additionally, as Sandhu et al. specifically discloses preventing the formation of  $\text{TiO}_2$ , one of skill in the art would not be motivated to look to a reference directed to forming  $\text{TiO}_2$  films.

Accordingly, the combination of Sandhu et al. in view of Giolando et al. cannot be relied on to establish a prima facie case of obviousness of claims 1-4, 12 and 14-15 (or corresponding new claims 16-18).

Sandhu et al. in view of Giolando in further view of Ameen et al.

Claims 5-7, 9 and 10 are rejected under 35 U.S.C. §103 (a) as being unpatentable over Sandhu et al. in view of Giolando as applied above, and further in view of U.S. Patent No. 6,635,569 to Ameen et al.

Sandhu et al. and Giolando are discussed above.

Ameen et al. is directed to a method of maintaining the stability of a plasma enhanced chemical vapor deposition (PECVD) which includes a cleaning process that facilitates reactor break-in, reactor and process recovery and process stabilization. Ameen et al. is concerned

with the buildup of Ti and other  $\text{TiCl}_x$  compounds on the reactor component surfaces to prevent the buildup from flaking off and contaminating wafers being processed in the reactor. (Ameen et al. at col. 7, lines 39-43). Ameen et al. discloses the use of cleaning gases such as  $\text{NF}_3$ ,  $\text{ClF}_3$  or  $\text{Cl}_2$  to remove the  $\text{TiCl}_x$ -containing residue from the reactor. Ameen et al. does not disclose a process for removing *TiO<sub>2</sub>-containing substances*.

As Ameen et al. does disclose a process for removing  $\text{TiO}_2$ -containing substances, it does not cure the deficiencies of Sandhu et al. and Giolando discussed above, and cannot be used in combination with Sandhu et al. or Giolando as the basis of a *prima facie* case of obviousness of claims 5-7, 9, and 10 (or corresponding new claims 19 and 20).

Sandhu et al. in view of Giolando in further view of Ameen et al. and Shang et al.

Claims 11 and 13 are rejected under 35 U.S.C. § 103 (a) as being unpatentable over Sandhu et al. in view of Giolando as applied above, and further in view of Ameen et al. and U.S. Patent No 5,788,778 to Shang et al.

Sandhu et al., Giolando, and Ameen et al. are discussed above.

Shang et al. is directed to a method of cleaning a deposition chamber that is used in fabricating electronic devices. Shang et al. discloses using a remote plasma to activate a cleaning gas. (Shang et al. at col. 2, lines 34-56). Shang et al. does not disclose a process for removing *TiO<sub>2</sub>-containing substances*.

As Shang et al. does not disclose a process for removing  $\text{TiO}_2$ -containing substances, it does not cure the deficiencies of the other references discussed above, and cannot be used in combination with these references as the basis of a *prima facie* case of obviousness of claims 11 and 13 which depend from claim 1.

Sandhu et al. in view of Giolando in further view of Shang et al.

Claim 8 is rejected under 35 U.S.C. § 103 (a) as being unpatentable over Sandhu et al. in view of Giolando as applied above, and further in view of Shang et al.

Sandhu et al., Giolando and Shang et al. are discussed above.

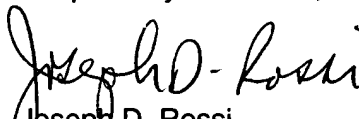
As discussed above, the combination of these references do not teach all the limitations of independent claims 1 and claim 15. Thus, these references cannot be used as the basis of a *prima facie* case of obviousness of claim 8 which depends on claim 1.

**Conclusion**

Applicants believe that the foregoing constitutes a complete and full response to the Action of record. Applicants respectfully submit that this application is now in condition for allowance. Accordingly, an indication of allowability and an early Notice of Allowance are respectfully requested.

The Commissioner is hereby authorized to charge the fee required and any additional fees that may be needed to Deposit Account No. 01-0493 in the name of Air Products and Chemicals, Inc.

Respectfully submitted,



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